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[Claim(s)]
[Claim 1]In a balancer device of a 4-cylinder engine in which crankpin arrangement has the 1st cylinder crankshaft they are [crankshaft] 0 degree, 2nd cylinder 90 degrees, 3rd cylinder 270 degrees, and 4th cylinder 180 degrees, A balancer device of a 4-cylinder engine having made crank rotation partial mass of an equivalent mass system of a piston crank chain into less than [of both-way partial mass] 1/2, and providing two balancer shafts, a direction and a uniform reverse direction, such as uniform velocity, in said crankshaft and parallel.
[Claim 2]A balancer device of the 4-cylinder engine according to claim 1 setting said crank rotation partial mass to 0.

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the balancer device which sets thoroughly the rolling vibration exciting moment of the circumference of the crankshaft by the primary inertia force [secondary], and an inertia couple and a primary inertia force to 0 about the balancer device of a modification sequence type 4-cylinder engine.
[0002]
[Description of the Prior Art]The 1st cylinder and the 4th cylinder are [the 2nd cylinder and the 3rd cylinder of crankpin arrangement of the 4-cylinder four cycle engine adopted widely conventionally] 180 degrees at 0 degree.
For a **** reason, all 4-cylinders are called 1 plain crank arrangement in 1 flat surface.
In such a 1 plain crank 4-cylinder engine, although the primary inertia force and an inertia couple are 0, the secondary rolling vibration exciting moment of the circumference of the crankshaft by the secondary inertia force and a primary inertia force remains.
[0003]If it is going to eliminate this secondary inertia force, it is necessary to a crankshaft to provide two balancer shafts, a direction and a 2X reverse direction, such as 2X, in the symmetrical position of cylinder both sides.
[0004]If it is going to eliminate a secondary [further] rolling moment, it is necessary to offset a balancer shaft in fixed quantity in the direction of a cylinder.

[0005]Such a balancer shaft needs to fulfill a fixed geometric condition, and the degree of freedom of a design is restricted substantially.
[0006]Since a balancer shaft turns by 2X of a crankshaft, with a high-rotational engine, it is accompanied by various problems of the endurance and the mechanical noise of a balancer shaft receptacle.
[0007]On the other hand, unlike the above-mentioned 1 plain crankpin arrangement, crankpin, [as 1st cylinder 0 degree, 2nd cylinder 90 degrees 3rd cylinder 270 degrees, and 4th cylinder 180 degrees] 2 plain crank arrangement structure where the 1st, the cylinder [4th] flat surface, and the 2nd and a cylinder [3rd] flat surface constituted rectangular cross 2 flat surface is proposed. Since the engine of such a 2 plain crankpin structure has the small denial operation of the double acting portion mass in cylinders compared with 1 plain crankpin arrangement, there is difficulty in respect of vibration isolation art, but. Conversely, in the motorcycle etc., engine combustion pressure is felt corporally in respect of the amplitude of vibration, an S/N ratio, and frequency, and since an acceleration feeling improves and drive feeling becomes very good, utilization of the vibration suppression art in such a 2 plain crank engine structure is desired.
[0008]An engine is made into 2 plain crankpin structure in order to solve the various problems of the above-mentioned 1 plain crankpin structure, Providing one balancer shaft of uniform counterrotation in a crankshaft and parallel, providing two balancer weight the 1st, the object for the 2nd cylinder, and for the 3rd and 4th cylinder on a balancer shaft, and reducing vibration of an engine is proposed (JP,S57-69173,A).
[0009]
[Problem to be solved by the invention]However, the rotation partial mass (it is assumed that it is a crankpin position equivalent and has turned to the reverse direction of a pin) of each cylinder of a 4-cylinder engine such given in a gazette needs to be 1/2 of the both-way partial mass of each cylinder fundamentally. However, supposing it is difficult to install the rotation portion corresponding to such mass in the same space by the same member as the 4-cylinder engine of 1 plain crankpin arrangement adopted widely conventionally and installs in the same space, Heavy-metal-izing of a balance weight and titanium-ization of a connecting rod are needed, it is disadvantageous in respect of technical composition, an assembly, and a price, and productivity worsens.
[0010]In a high-rotational speed engine, it becomes a problem in respect of the endurance due to a torsion natural-frequency fall.
[0011]On the other hand, this invention persons make a primary moment the minimum in the above-mentioned crank arrangement and different arrangement, Although the improvement of acceleration and an oscillating feeling was aimed at using 2 plain crank (1st cylinder 0 degree, 2nd cylinder 180 degrees, 3rd cylinder 270 degrees, 4th cylinder 90 degrees) of the form that a secondary moment becomes the maximum, control of vibration with the primary secondary moment was difficult. Then, this invention persons changed crank type voice, the secondary moment adopted 2 plain crank of the maximum [moment / primary] by 0, and it planned removing the primary moment thoroughly by a balancer.
[0012]This invention is made in view of the above-mentioned point, and it can be produced without changing the conventional production facility greatly. The purpose is offer of the balancer device of the modification sequence type 4-cylinder engine in which all the rolling vibration exciting moments of the circumference of the crankshaft by the primary inertia force [secondary] and the inertia couple, and a primary inertia force are set to 0.

[0013]
[Means for solving problem]In order to attain said purpose, crankpin arrangement in this invention 1st cylinder 0 degree, In the balancer device of the 4-cylinder engine which provided two balancer shafts, a direction and a uniform reverse direction, such as uniform velocity, in said crankshaft and parallel to the 2nd cylinder crankshaft (90 degrees, 3rd cylinder 270 degrees, and 4th cylinder 180 degrees), The balancer device of the 4-cylinder engine making crank rotation partial mass of an equivalent mass system of a piston crank chain into less than [of both-way partial mass] 1/2 is provided.
[0014]If the rotation partial mass of a crank considers it as smallness from 0 or 1/2 of the both-way partial mass of each cylinder, [in such a balancer device] To a crankshaft, the primary pitching vibration exciting moment of the circumference of a crankshaft can be offset with the primary pitching vibration exciting moment and primary yawing vibration exciting moment which two balancer shafts, a direction and a uniform reverse direction, such as uniform velocity, generate, and can be negated.
[0015]
[Working example]The balancer device of this invention is further explained using drawing 1, drawing 2, and drawing 3 below. In the following explanation, the coordinate system uses the right-hand coordinate system the z axis turned [coordinate system] to space this side. Let the hand of cut of a crank be a counterclockwise rotation, in view of the space this side side.
[0016]Drawing 1 is a composition explanatory view showing the 1 cylinder of the 4-cylinder engine in which this invention is applied, and drawing 2 is an explanatory view of the crank arrangement of a 4-cylinder. The crank 20 combined with the crankshaft 6 is connected with the connecting rod 21 via the crankpin 23, and also is connected with the piston 22 via the gudgeon pin 24. The material point of the both-way partial mass of each cylinder is a position of the gudgeon pin 24, and the material point of rotation partial mass is a position of the crankpin 23. As shown in drawing 2, as for the crank (0 degree and the 2nd cylinder) 20b, in the crank (90 degrees and the 3rd cylinder) 20c, the crankpin arrangement of each cylinder of a 4-cylinder of the crank (270 degrees and the 4th cylinder) 20d is [this engine / cylinder / 1st / crank 20a] 180-degree 2 plain crankpin arrangement structure.
[0017]About the vibration exciting moment which the both-way partial mass of the engine of such crank structure generates, it is computed as follows.
[0018]In distance between cylinders, when l and both-way partial mass are set to m and omega and a crank radius are set to r for angular velocity, primary pitching moment My1 is denoted by the following expression (1).
[0019]
[Mathematical formula 1]

$$\begin{aligned} My1 &= -mr\omega^2 l\cos(\theta+90^\circ) - 2mr\omega^2 l\cos \\ &\quad (\theta+270^\circ) - 3mr\omega^2 l\cos(\theta+180^\circ) \\ &= -mr\omega^2 l\cos(\theta+90^\circ) - 3mr\omega^2 l\cos\theta \\ &= mr\omega^2 l\sin\theta - 3mr\omega^2 l\cos\theta \\ &= \sqrt{10}mr\omega^2 l\cos(\theta+18.4^\circ) \quad \text{----- (1)} \end{aligned}$$

[0020]Since the secondary paragraph is set to 0 like the following expression (2), secondary pitching moment My2 is My2=0.

[0021]
[Mathematical formula 2]

$$1\sin(2\theta+2\times90^\circ)+21\sin(2\theta+2\times270^\circ)$$
$$+31\sin(2\theta+2\times180^\circ)=0 \quad \text{-----(2)}$$

[0022]If rotation partial mass (it is assumed that it is a crankpin position equivalent and has turned to the reverse direction of a pin) of a crankshaft is set to smallness, A< 1, and A+B=1 from 1/2 of the both-way partial mass of each cylinder, the moment of the following expression (3) will be generated. Here, A and B are the ratios showing the assignment rate of the rotation partial mass of a crankshaft, and direction balancers, such as uniform velocity, for example, when the rotation partial mass of a crankshaft is 1/2 of the both-way partial mass of each cylinder, they become the structure which are A= 1 and B= 0 and does not have direction balancers, such as uniform velocity. This is equivalent to the structure of JP,57-69173, A. In the case of Claim 2 of an application concerned, it is set to A= 0 and B= 1. The value of minus may be sufficient as A.
[0023]
[Mathematical formula 3]

$$Myc1=-A/2\sqrt{10}mr\omega^2 1\cos(\theta+18.4^\circ) \quad \text{-----(3)}$$

[0024]Here, to a crankshaft, the moment of the following expression (4) is generated by the balancer shaft of directions, such as uniform velocity, and, similarly the moment of expression (5) is generated by the balancer shaft of a uniform reverse direction.
[0025]
[Mathematical formula 4]

$$My1b1=-B/2\sqrt{10}mr\omega^2 1\cos(\theta+18.4^\circ) \quad \text{-----(4)}$$

[0026]
[Mathematical formula 5]

$$My1b2=-1/2\sqrt{10}mr\omega^2 1\cos(-\theta-18.4^\circ) \quad \text{-----(5)}$$

[0027]Thereby, it is set to My1+Myc1+My1b1+My1b2=0, and a primary pitching moment is eliminated.
[0028]The vibration exciting moment of the x direction by the crankshaft and a balancer shaft serves as expression (6-1) (6-2) (6-3) shown by (several 6) of the following, respectively.
[0029]
[Mathematical formula 6]

$$Mx1c1=-A/2\sqrt{10}mr\omega^2 1\sin(\theta+18.4^\circ) \quad \text{-----(6-1)}$$
$$Mx1b1=-B/2\sqrt{10}mr\omega^2 1\sin(\theta+18.4^\circ) \quad \text{-----(6-2)}$$
$$Mx1b2=-1/2\sqrt{10}mr\omega^2 1\sin(-\theta-18.4^\circ) \quad \text{-----(6-3)}$$

[0030]Thereby, it is set to Mx1c1+Mx1b1+Mx1b2=0, and is denial **** mutually.
[0031]Next, the secondary rolling vibration exciting moment of the circumference of the crankshaft by a primary inertia force is explained.
[0032]In the 1st cylinder that is crankpin arrangement (1 plain crankpin arrangement) of the 4-cylinder engine adopted widely conventionally, 4th cylinder 0 degree, the 2nd cylinder, and 3rd cylinder 180

degrees, Vibration exciting moment Mz1 by a primary inertia force is expressed like the following expression (7), becomes a secondary rolling vibration exciting moment of the circumference of a crankshaft, and remains.

[0033]

[Mathematical formula 7]

$$\begin{aligned} Mz1 = & -1/2 m r^2 \omega^2 \sin(2\theta) \\ & -1/2 m r^2 \omega^2 \sin(2\theta + 180^\circ) \\ & -1/2 m r^2 \omega^2 \sin(2\theta + 180^\circ) \\ & -1/2 m r^2 \omega^2 \sin(2\theta) \\ = & -2 m r^2 \omega^2 \sin(2\theta) \qquad \text{-----(7)} \end{aligned}$$

[0034]Crankpin arrangement in the engine of this invention On the other hand, 1st cylinder 0 degree, It is the 2nd cylinder 2 plain crankpin arrangement (90 degrees, 3rd cylinder 270 degrees, and 4th cylinder 180 degrees), and as shown in the following expression (8), vibration exciting moment Mz1 by a primary inertia force is set to Mz1=0, and it is mutually negated in each cylinder.

[0035]

[Mathematical formula 8]

$$\begin{aligned} Mz1 = & -1/2 m r^2 \omega^2 \sin(2\theta) \\ & -1/2 m r^2 \omega^2 \sin(2\theta + 90^\circ) \\ & -1/2 m r^2 \omega^2 \sin(2\theta + 270^\circ) \\ & -1/2 m r^2 \omega^2 \sin(2\theta + 180^\circ) \\ = & 0 \qquad \text{-----(8)} \end{aligned}$$

[0036]In the above-mentioned explanation, since it calculated by the method of dividing connecting rod mass into general both-way partial mass and rotation partial mass, in the moment computation of the circumference of a crankshaft, the value using the moment of inertia of the circumference of a connecting rod center of gravity has an error called correction torque. However, since it was comparatively small, this error was disregarded.

[0037]Drawing 3 is a basic lineblock diagram of the balancer device concerning the embodiment of above-mentioned this invention. The gear foil 31 is fixed to the crankshaft 6, and the 1st balancer shaft 11 is rotated in the directions, such as uniform velocity, to the crankshaft 6 via the chain 30 which engages with this gear foil 31. A uniform reverse direction is made to rotate the 2nd balancer shaft 12 to the 1st balancer shaft 11 via a pair of gears 14 and 15. Thereby, one of two balancer shafts rotates other one to a uniform reverse direction in the directions, such as uniform velocity, to a crankshaft. At this time, rotation partial mass is constituted so that it may become smaller than 1/2 of both-way partial mass.

[0038]Next, another embodiment of this invention is described. This embodiment sets rotation partial mass of a crankshaft to 0 in the 4-cylinder engine of 2 plain crankpin arrangement. It replaces with the expression (4) and (5) of said embodiment, and directions, such as uniform velocity, and a uniform reverse direction are made to generate the moment of the following expression (9) and (10) to a crankshaft in this embodiment, respectively.

[0039]

[Mathematical formula 9]

$$My1b1 = -1/2\sqrt{10}\, m\, r\, \omega^2\, l \cos(\theta + 18.4°) \quad \text{-----(9)}$$

[0040]

[Mathematical formula 10]

$$My1b2 = -1/2\sqrt{10}\, m\, r\, \omega^2\, l \cos(-\theta - 18.4°) \quad \text{-----(10)}$$

[0041]Thereby, since it is Myc1=0, like the case of said embodiment, it is set to My1+Myc1+My1b1 +My1b2=My1+My1b1+My1b2=0, and a primary pitching moment is eliminated.

[0042]The vibration exciting moment of the x direction by a balancer shaft serves as the following expression (11-1) (11-2).

[0043]

[Mathematical formula 11]

$$Mx1b1 = -1/2\sqrt{10}\, m\, r\, \omega^2\, l \sin(\theta + 18.4°) \quad \text{-----(11-1)}$$

$$Mx1b2 = -1/2\sqrt{10}\, m\, r\, \omega^2\, l \sin(-\theta - 18.4°) \quad \text{-----(11-2)}$$

[0044]Therefore, it is set to Mx1b1+Mx1b2=0, and negates each other.

[0045]About the secondary rolling vibration exciting moment of the circumference of the crankshaft by a primary inertia force, like said embodiment, it is set to Mz1=0 and negates each other in each cylinder.

[0046]Drawing 4 is a left side view of the motorcycle in which this invention is applied. The front wheel 1 is supported by the front fork 3 connected with the head tube 2, and 4-cylinder engine 5 is laid below the fuel tank 4 of the mainframe front part connected to the head tube 2. The crankshaft 6 of this engine 5 is allocated in the cross direction, and each cylinder of the engine 5 is allocated along with the crankshaft 6. Rotary motion of this crankshaft 6 is transmitted to the rear wheel 8 via the chain 7.

[0047]This 4-cylinder engine 5 in which this invention is applied is the above-mentioned 2 plain crankpin arrangement, and the balancer device which has two balancer shafts is formed.

[0048]Drawing 5 is a basic lineblock diagram of the balancer device (device on the right-hand side of drawing 6) concerning the embodiment of this invention. Drawing 5 (A) is a ** figure (cross section) from the vehicles side, and drawing 5 (B) is a ** figure (cross section) from the vehicles front of drawing 6, i.e., the direction. This balancer device 10 is constituted by a crankshaft, the 1st balancer shaft 11 of directions, such as uniform velocity, a crankshaft, and the 2nd balancer shaft 12 of a uniform reverse direction. Each balancer shafts 11 and 12 are equipped with the balance weight 13. An engine crankshaft and direct coupling may be sufficient as the 1st balancer shaft 11, or it may be connected so that it may become in the directions, such as uniform velocity, to a crankshaft via a transmission mechanism with suitable gear, chain, etc. fixing the 1st gear 14 to this 1st balancer shaft 11, and fixing this 1st gear 14 and the 2nd gear of the equal diameter said number of teeth to the 2nd balancer shaft 12 -- the [these] -- the 1 2nd gear 14 and 15 is engaged. In this, the 2nd balancer shaft 12 rotates to a uniform reverse direction to a crankshaft.

[0049]Such a balancer device 10 is attached to both sides of a car body as shown in drawing 6. It is symmetrical arrangement of as opposed to the vehicle center line of the right side device of drawing 6 about axial arrangement of the device on the left-hand side of drawing 6. About the phase angle of the balance weight 13, it is a position with a reverse phase angle of 180 degrees to each of the balancer shafts 11 and 12. That is, in the case of this embodiment, it is constituted by a total of four balancer

shafts of a direction and the same uniform reverse direction of 1 pair, such as uniform velocity which is one pair of right and left. Such composition is also included with "two balancer shafts" of the invention in this application. Although it had composition which makes a uniform reverse direction rotate the 2nd balancer shaft 12 of the above to a crankshaft via the 1st balancer shaft 11 using the gears 14 and 15 in the above-mentioned embodiment, It may replace with such composition, and it may constitute so that rotation of a uniform reverse direction may be obtained from a crankshaft via a suitable transmission mechanism. It is arrangement of the balancer device which can also stop the projection amount to the cross direction of a crankshaft portion few, and do not decrease in number an angle of bank, without changing the layouts around [engine] the motorcycle of the case former of this embodiment (arrangement of an engine-loading position, a vaporizer, etc., etc.).

[0050]

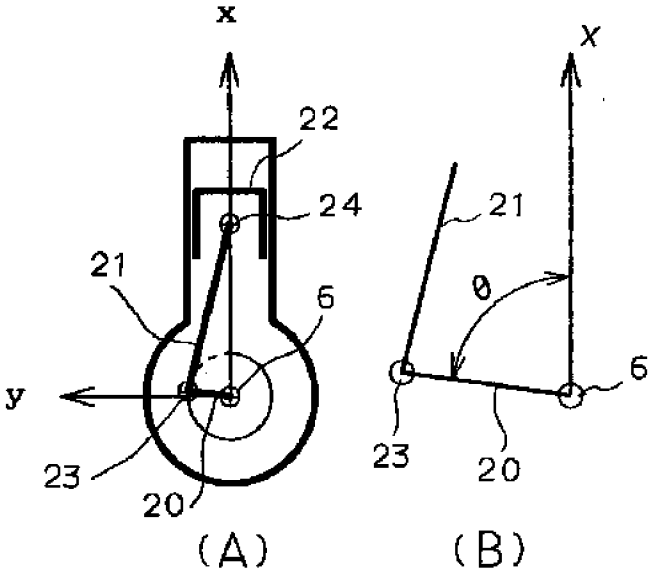
[Effect of the Invention]In [as explained above] the in-series 4-cylinder engine of 2 plain crankpin arrangement at this invention, Since the rotation partial mass of a crankshaft is constituted as less than [of both-way partial mass] 1/2 using two balancer shafts, a direction and a uniform reverse direction, such as uniform velocity, to a crankshaft so that the vibration exciting moment of x, y, and the direction of z may be set to 0, Without enlarging crank-case space so much, control engine vibration and The primary inertia force [secondary] and an inertia couple, All the rolling vibration exciting moments of the circumference of the crankshaft by a primary inertia force are set to 0, When [this] the engine of comfortable drive feeling is realizable, if it faces actually producing an engine and necessary minimum change, such as pinout and an oil passage, is made to the conventional production facility, it is usable in an established product line. Since two balancer shafts are couple-of-forces balancers, if parallel to a crank, there will be no restriction of an installed position. Therefore, it can provide in the suitable position of the outside of a crankshaft end, or the space part of a flank, and the balancer shaft of directions, such as uniform velocity, can be made to serve a double purpose as a reserving gear of the balancer shaft of a uniform reverse direction, and an engine with a large degree of freedom of a design is obtained. The reserving gear of the balancer shaft of directions, such as uniform velocity, and the balancer shaft of a uniform reverse direction can also be made to serve a double purpose as a drive shaft of a tooth-back generator. When rotation partial mass of a crankshaft is set to 0 (in the case of Claim 2), a crankshaft has many which can carry out common use of the conventional production facility, the crankcase, etc. in conventional 1 plain crank and same size.

[0051]By making rotation partial mass of a crankshaft into less than 1/2 more greatly than 0, a part of couple of forces (moment) required for oscillating balance can be realized with the size and phase angle of a web core of a crank, and an insufficiency can be provided with the balancer shaft of directions, such as uniform velocity. Therefore, the size of direction balancer shafts, such as uniform velocity, can be made small compared with the case where rotation partial mass is turned down the 0th place, occupancy space is made small, and energy consumption can also be lessened. That is, when a tooth-space margin is in a crank case, a balancer device can be miniaturized by making the assignment rate of a balancer shaft small for the assignment rate of the crank itself greatly among moments required to negate vibration.

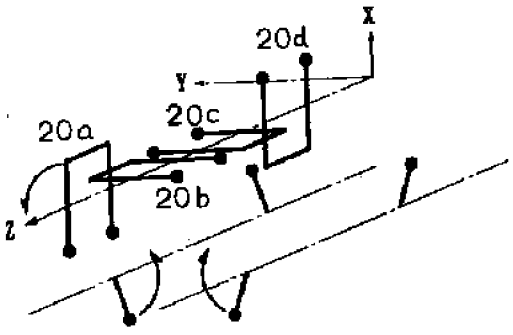
[Brief Description of the Drawings]

[Drawing 1]It is an explanatory view for the moment computation for all directions of the balancer device of this invention.
[Drawing 2]It is an explanatory view of the crankpin arrangement of this invention.
[Drawing 3]It is a basic lineblock diagram of the balancer device of this invention.
[Drawing 4]It is a side elevation of the motorcycle in which this invention is applied.
[Drawing 5]It is a basic lineblock diagram of the balancer device of this invention.
[Drawing 6]It is a front view of the motorcycle provided with the balancer device of this invention.
[Explanations of letters or numerals]
6: Crankshaft
10: Balancer device
11: 1st balancer shaft
12: 2nd balancer shaft
20: Crank
21: Connecting rod
22: Piston
23: Crankpin
24: Gudgeon pin

[Drawing 1]



[Drawing 2]



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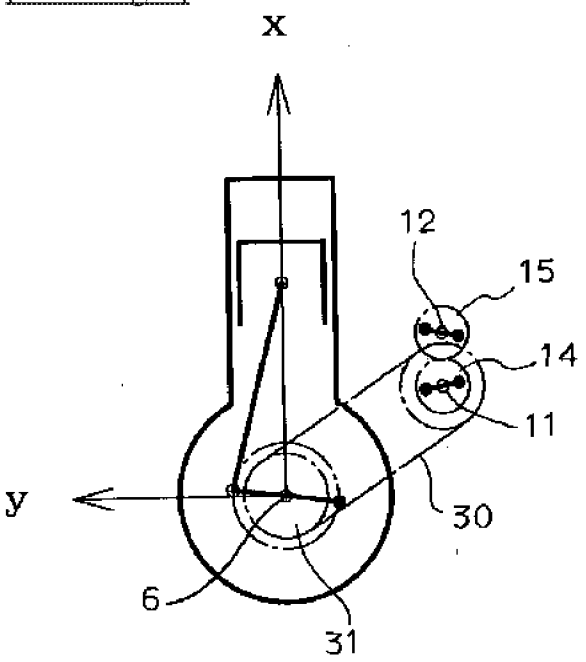

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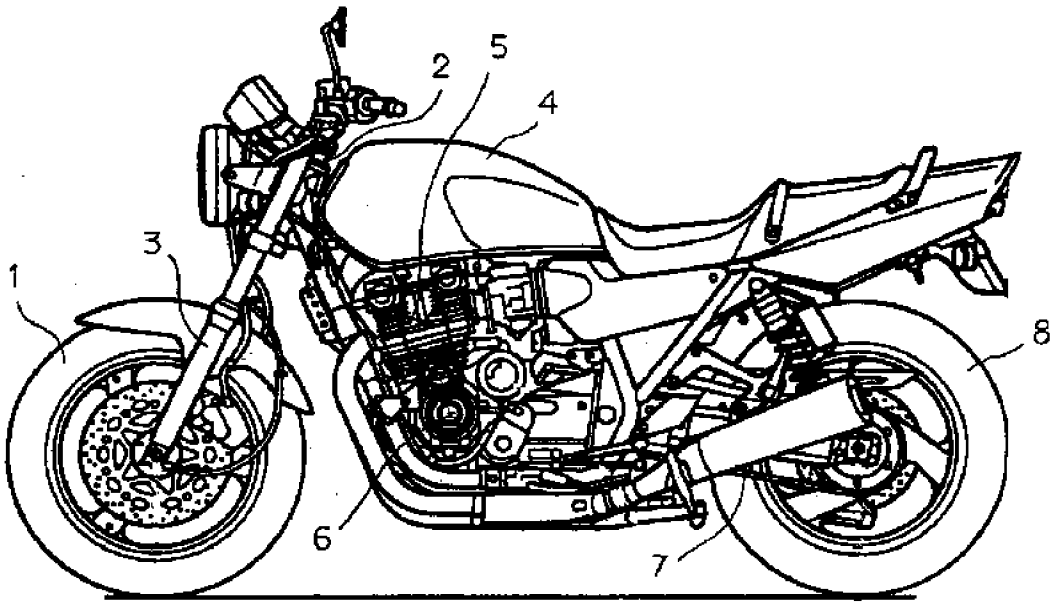

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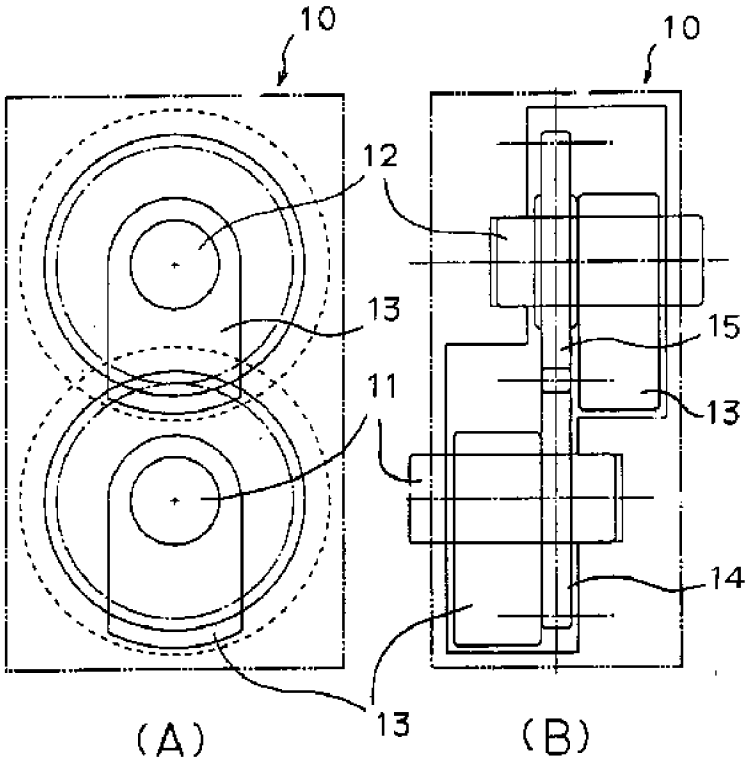

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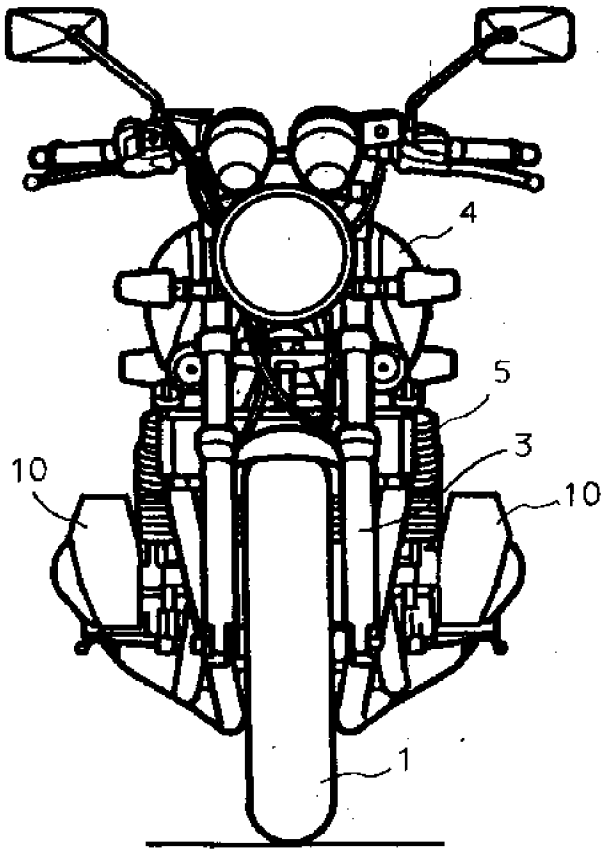

[Translation done.]